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Voices of Tradition: Agro-Ecological and Land–Water Management Systems among Apatani Tribe of Ziro Valley, India

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Abstract

The Apatani community of Ziro Valley is widely acknowledged for its indigenous and sustainable land and water management practices. Their traditional system, which integrates wet rice cultivation with fish rearing on terraced fields, is supported by a well-organized network of irrigation channels, bamboo pipelines, and water distribution systems. These ecological practices have received considerable attention in academic and policy circles for their efficiency, sustainability, and adaptability.

The study examines the traditional land and water use practices of the Apatani community, focusing on the functioning and sustainability of their unique Agro-ecological system. Based on qualitative field interviews with community members across different age groups and supported by secondary sources, the research documents the diverse practices involved in maintaining this system. It highlights activities such as terrace construction and maintenance, irrigation management, seed selection, rice cultivation, composting, and the upkeep of home gardens. These interconnected practices and knowledge systems collectively contribute to ecological balance, efficient resource utilization, and long-term resilience of the Agro-ecosystem.

The study also identifies emerging challenges, including modernization, youth migration, and environmental change, which threaten the continuity of these traditional practices. Such transformations are leading to shifts in knowledge transmission and weakening of community-based management systems. The paper concludes by recommending adaptive and inclusive strategies that strengthen traditional ecological knowledge while integrating appropriate innovations. By emphasizing community-based resource management and sustainable practices, this research highlights the continued relevance of indigenous Agro-ecological systems in achieving sustainable development.

Keywords: *Apatani, Ziro Valley, Rice-Fish Cultivation, Water Management, Community Participation, Sustainability, Indigenous Knowledge, Agro-Ecology*

1. Introduction

The sustainable management of land and water resources has become increasingly important in the face of environmental degradation, climate change and growing resource scarcity. Sustainable land and water management refers to the responsible and balanced use of natural resources in a manner that meets present needs while preserving ecological functions for future generations. Such practices aim to conserve soil fertility, maintain water quality, prevent land degradation and promote biodiversity. Around the world, many indigenous and traditional communities have evolved localized systems of natural resource use rooted in experiential knowledge and ecological wisdom. These systems, often passed down through generations via

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oral traditions and cultural practices, serve not only as the basis for livelihood security but also as valuable models for environmental resilience and sustainability.

Among these communities, the Apatani tribe of Arunachal Pradesh presents a particularly notable example of indigenous ecological management. The Apatani tribe inhabit the Ziro Valley, located in the Lower Subansiri district in the Eastern Himalayan foothills. Situated at approximately 1,525 meters above sea level, the valley lies between 27°32' N to 27°37' N latitude and 93°48' E to 93°52' E longitude, about 106 kilometers from the state capital, Itanagar. Ziro is characterized by its rolling hills, perennial streams and dense forests, making it not only a scenic landscape but also a model of ecological sustainability[1]. Unlike many neighbouring tribes who practice shifting cultivation locally known as jhum cultivation, the Apatani have developed a system of permanent wet rice cultivation. They have settled in the valley for centuries and constructed terraced fields that are irrigated through a well-designed network of water channels and bamboo pipelines. This unique agro-ecological model integrates wet rice cultivation with fish farming, maximizing land and water use efficiency. Even the embankments of the terraces are used for millet cultivation, showcasing the community's deep understanding of land optimization[2].

The Apatani farming system is guided by a zero-waste philosophy. According to Aiyadurai, organic waste from kitchens and livestock is reused in irrigation channels, enriching soil fertility and contributing to nutrient recycling. Water is sourced from higher elevations and distributed through bamboo-framed earthen canals and small dams. This closed-loop system not only supports crop productivity but also reflects a deep ecological consciousness. In recognition of its environmental significance and cultural uniqueness, the Ziro Valley was nominated for UNESCO World Heritage Site status in 2006.

Beyond its technical and ecological components, the Apatani system is sustained through strong community collaboration. A vital yet often underrepresented element of this system is the distinct and complementary roles played by men and women. In Apatani society, gender roles are well-defined but interdependent. Men typically engage in physically intensive tasks such as terrace construction, canal maintenance and land clearing, while women are involved in seed selection, rice transplantation, weeding, harvesting and maintaining home gardens. Women also possess valuable ecological knowledge related to local biodiversity, soil quality and pest control.

The study seeks to comprehend how these gender-specific roles contribute to the sustainability of Apatani land and water management. It also investigates how these roles are changing due to socio-economic transformations, including modernization, migration and climate change. Understanding and supporting the contributions of both men and women is crucial not only for preserving Apatani ecological knowledge but also for informing inclusive environmental policies and rural development strategies in the Northeast region of India and beyond.

2. Objectives of Study

The study has three primary objectives:

- To document and analyse the traditional land and water management practices of the Apatani community in Ziro Valley.
- To examine the gender-specific responsibilities and contributions of Apatani men and women in sustaining traditional land and water management practices.
- To identify the key challenges faced by the Apatani community in conserving their traditional land and water management practices.

[1] Kago Yamang & Nandini C. Singh, *Women, IKS and Sustainable Development: A Perspective on the Apatani Tribal Women of Ziro Valley, (Arunachal Pradesh)*, International Journal of Recent Advances in Multidisciplinary Topics, RESAIM Publishing, India, 2021, P.P. 110–115.

[2] NITI Aayog, *National Institute of Labour Economics Research and Development Fifty-Fifth Annual Report 2017-18*, Narela Institutional Area, Delhi, 2017.

3. Research Methodology

The study adopted a qualitative and descriptive research approach to examine the traditional land and water management practices of the Apatani community, with particular emphasis on gender roles and conservation challenges. The research relied on both primary and secondary sources of data**.** Primary data were collected through semi-structured interviews with selected Apatani men and women aged between 40 and 65 years, who possess extensive experiential knowledge of traditional agricultural and ecological practices. An open-ended interview guide was designed to facilitate discussion and allow participants to freely share their experiences and perspectives on farming practices, water management, composting techniques, and conservation practices. The total sample size of 150 (one hundred fifty) were collected. The fieldwork was conducted across five villages in Ziro Valley, Arunachal Pradesh**:** Mudang Tage, Bamin Michi, Dutta, Hari, and Hong. In addition to interviews, field notes and observational records were maintained to capture contextual understandings and support the qualitative analysis. The study adopted a gender-inclusive approach, incorporating the perspectives of both men and women in order to ensure a more balanced and comprehensive understanding of traditional resource management practices.

Secondary data were obtained from books, peer-reviewed journal articles, research reports, and credible online platforms, including *Down to Earth*, *India Water Portal*, and *The Better India*. These sources provided important contextual background and were used to corroborate and complement the primary field findings**.**

4. The Agro-Ecological System

The Apatani tribe of the Ziro Valley in Arunachal Pradesh's Lower Subansiri district, is internationally recognized for its ecologically sustainable and culturally embedded land and water management system. They have developed a permanent and settled form of agriculture.[3] A key feature of the Apatani agro-ecological system is the integration of wet rice cultivation with fish rearing, along with *sarse* (millet) grown on the *ager* (bunds) that divide the fields. This paddy-cum-fish farming, adopted in the 1960s with governmental support for self-employment, has proven to be both productive and sustainable.[4]

The land-use system of Apatani is based on traditional classifications guided by customary rules and ecological knowledge. Land is carefully zoned into residential areas, irrigated and dry cultivation plots, bamboo-pine gardens, community forests and burial grounds ensuring optimal use of limited land resources while supporting both ecological balance and the subsistence needs of a dense population in the valley. Approximately 600 hectares of irrigated land on the Ziro plateau are used for this purpose. The system has achieved both food security and environmental sustainability, earning global recognition. In 2014, it was designated a Globally Important Agricultural Heritage System (GIAHS) by the Food and Agriculture Organization.

In addition to agricultural innovation, the Apatani have conserved Sacred Groves - patches of forest preserved through indigenous ecological knowledge and cultural taboos. These groves, integral to the valley's biodiversity are home to endangered and endemic species, including medicinal plants, orchids, ferns and bird species like hornbills and pheasants. The preservation of these groves demonstrates the Apatani community's enduring commitment to sustainable land use and ecological management.

4.1 Wet Rice Cultivation on Terraces

Wet rice cultivation on terraced fields, locally called *Aji* forms the foundation of the Apatani land-use system. These terraces are carefully built and bordered by compacted earthen embankments called *Ager* to retain water

[3] Santanu K. Patnaik, *Multifunctional Agriculture as a Holistic Tool in Addressing Sustainability Issues Among Mountain Communities of Ziro valley, Arunachal Pradesh*, Savitribai Phule Pune University, Pune, 2020.

[4] Padi Hana, *Modernity and Transformation in Tribal Life: A Study of the Apatani of Ziro Valley,* International Journal of Humanities and Social Science Invention, Invention Journals, India, 2019.

and prevent erosion[5] . These embankments also act as paths and field boundaries. Though the fields are privately owned, irrigation is managed collectively. Each terrace has an inlet and outlet to control water flow. Water comes from a single rivulet that supports the whole valley and is channelled through canals called *Bogo*. Channels known as *Pakho* or *Heteh* are used to regulate water between fields. These are opened or sealed with *Gartin Nanii*, a mix of straw, grass and mud depending on water needs. Community members come together to repair the channels before sowing.

The Apatani follows a mono-cropped rice farming system without using animals or machines. All farm work such as ploughing, transplanting, weeding and harvesting is done manually, often by the whole household. This system is both eco-friendly and culturally significant.The agricultural cycle follows a traditional calendar aligned with local festivals like *Dree*, which marks fertility and prosperity. Farming begins in *Nenke Piilo* (December) with field cleaning and compost application. In *Murung Piilo* and *Parge Piilo* (January–February), men repair irrigation structures. In *Myoko Piilo* (March), *Miding* (nurseries) are prepared and rice seeds are sown. Fields are weeded again in *Halying Piilo* (April) before transplanting begins. Transplantation peaks in *Enda Piilo* (May), followed by repeated weeding in *Empii* and *Mihlo* or *Dree Piilo* (June–July). Harvesting takes place from *Hahlo Piilo* (August) to *Ehmo Piilo* (November).

The Apatani grow about 16 varieties of rice and 4 types of millet. *Emo, Pyaping* and *Mipya* are the most common. These traditional varieties give high yields, three to four times higher than regional averages without chemical inputs. They use compost, cow dung and plant waste, and avoid fertilizers and pesticides to maintain soil health and biodiversity. The Apatani also practice crop diversification. *Areh Emoh* (early-ripening rice) is grown in distant fields with less water, while *Haso Emoh* (late-ripening rice) is grown closer to the village with better irrigation. This system is believed to be passed down from *Abotani*, the mythical ancestor of the Apatani.[6] Farming is central to their economy and social status [7]. Land is a symbol of wealth, and large landholdings are linked with higher status and better marriage prospects.

4.2 Rice-Fish Integration: A Unique Agro-Ecosystem

One of the most distinctive features of the Apatani agro-ecological system is the integration of fish rearing with wet rice cultivation, known locally as *Aji-Ngwyi* (paddy-cum-fish system). Practiced during the rice-growing season, *Ngwyi Amii* (fish fingerlings) are released into the flooded terraces. These fish feed on pests and weeds, help oxygenate the water and their waste naturally fertilizes the soil. This supports high rice yields without the use of chemical fertilizers. A key feature of this system is the use of shallow pits or channels within each field, called *Heteh* or *Pakho*. During the monsoon, these terraces are flooded to a depth of 5-10 cm, allowing the fish to move freely. In the dry season, the pits retain water serving as a refuge for fish and supporting their growth.[8]

The Apatani rears both native and commercial fish species. Local species like *Tali ngwyi* (Channa spp), *Papi Ngwyi* (Puntius spp). and *Ngilyang Ngwyi* (Schizothorax spp.) are found naturally in irrigation streams. With government support, commercial fish like common carp (Cyprinus carpio), silver carp and grass carp have been introduced. Among these, common carp is the most popular due to its strong survival and growth rate[9]. This integrated system provides many ecological advantages. Organic manure used in the fields supports both soil and fish health. The movement of fish helps reduce pests and weeds, limiting the need for synthetic pesticides.[10] This makes the practice environmentally sustainable. This system boosts land

[5] Singh et al., *Apatani Paddy-cum-Fish Cultivation: A Traditional Ecological Knowledge-Based Farming System,* Vigyan Sanchar Bhawan, K.S. Krishnan Marg, New Delhi 110012, India, 2013.
[6] S.C. Rai, *Apatani paddy-cum-fish cultivation: An Indigenous Hill Farming System of North East India,* Vigyan Sanchar Bhawan, K.S. Krishnan Marg, New Delhi, India, 2005.
[7] Haimendorf, *The Apatanis and their Neighbours A Primitive Civilization of the Eastern Himalayas,* London Routledge & Kegan Paul New York, The Free Press of Glencoe, 1962.
[8] Opcit. Rai, 2005
[9] Wishfully Mylliemngap, *Agrobiodiversity and Natural Resource Management in Traditional Agricultural Systems of Northeast India,* The Grassroots Institute, Canada, 2021.
[10] Opcit. 2005.

productivity and ensures ecological balance in the valley. In terms of output, the *Aji-Ngwyi* system yields 400-500 kg of rice per hectare - three to four times more than average yields in other parts of the state. The irrigation setup-bamboo pipes and earthen canals draws water from forest streams into terraced fields, reducing erosion and saving water.[11] This system is guided by traditional ecological knowledge, including skills in water management, trench building and fish-rice coordination passed down over generations through close observation and experience.

5. Traditional Water Management Techniques

Since the Apatani plateau lacks large rivers or lakes, the community relies on small perennial streams and rainwater. To use this limited water efficiently, they have developed a gravity-based irrigation system. It starts with diverting water from a stream at a higher elevation using a temporary bamboo or wooden dam called *Borang*. This structure controls the flow and stores water for distribution. From the *Borang*, water flows through narrow irrigation channels called *Siigang*, made by digging along slopes or using split bamboo. These channels carry water to distant fields with minimal loss. Each paddy field is surrounded by raised embankments called *ager*, and has one inlet and two outlets, known as *Hubur*. One outlet drains excess water; the other is used during paddy and fish harvesting. Water moves in a step-wise or cascading system, from one terrace to the next through these inlets and outlets. This reduces wastage and allows water to be reused across many fields.

This irrigation is vital for integrated fish farming. Trenches or pits called *Heteh/Pakho* are dug inside paddy fields. In the monsoon, they fill with water, allowing fish to move freely. In the dry season, the pits hold enough water for the fish to survive and grow. A unique feature of this system is its dependence on community effort. Villagers work together to build and maintain *Borang, Siigang, Ager* and other parts. Cleaning channels, repairing embankments and sharing water fairly are collective duties. This strengthens community ties and encourages shared responsibility. Overall, the Apatani system is eco-friendly and supports agrobiodiversity by conserving water, soil and fish species. It is a low-cost, decentralized model that balances environmental care with local livelihoods.

5.1 Organic Composting and Soil Fertility Management

For the Apatani, soil fertility is not just a farming task, it is a cultural and ecological responsibility. Their farming practices, including composting and fertilization are closely linked with traditional values, seasonal rhythms and festivals. This practice enhances efficient recycling of all organic material. With limited land and no use of external chemical inputs, they have developed a self-sustaining system. Their *Aji-Ngwyi* (rice-fish farming) depends on healthy soil. Instead of synthetic fertilizers, they rely on organic compost made from traditional and locally available materials. Compost is prepared using *piina* (rice husks), ashes from *mubu* (kitchen fires), *muyu* (burnt straw), *liisi* (decomposed straw), *tamih* (weeds), *ankho* (stalks), pig and poultry manure, household waste and cow dung.[12] Leaf litter and forest biomass collected from nearby forest patches also support this composting process and maintain nutrient cycles.

Since the same fields are used every year, Apatani take care to avoid soil exhaustion. Compost is made in pits near the house or fields, known as *Giila*, where materials are left to decompose over time. This process follows traditional knowledge about moisture levels, seasonal timing, and natural microbial activity. Once ready, the compost is carried to the fields and applied before transplanting rice seedlings. Green manure is also used by letting legumes and wild plants grow on *ager* (field bunds), which improves nitrogen levels and microbial life in the soil. These organic methods help keep the soil fertile and reduce dependence on

[11] K. N. Chaudhuri & S. Chaudhuri, *The Art of 'Organic' Living: Lessons from Apatani Women in Ziro Valley of Arunachal Pradesh in Northeast India,* Jogamaya Devi College, Kolkata, 2022.

[12] Yani et al., *Prioritization Strategies for the Resources of Traditional Paddy-cum-Fish Culture in Lower Subansiri District of Arunachal Pradesh, India,* Department of Agricultural Economics, Nagaland University, SASRD, Dimapur , 2018.

chemicals, which can harm the land and water. Compost adds nutrients, holds moisture and improves soil structure, making it more resistant to erosion and climate changes.

In interviews, both men and women stressed the importance of organic compost in Apatani farming. "We never throw away weeds. We pile them in the field and after they rot, we spread them. It becomes good manure," said a 53-year-old female farmer from Bamin Michi. Ash from kitchen fires is also commonly used in home gardens. These traditional methods reflect a circular, zero-waste approach to farming, where every natural resource is reused and valued as part of a balanced ecosystem.

6. Conservation Challenges in Traditional Land and Water Management Practices

The Apatani community of Ziro Valley in Arunachal Pradesh is widely recognized for its indigenous knowledge in sustainable agriculture, particularly in land and water management. However, in recent decades, several factors have threatened the continuation and effectiveness of these traditional practices. These challenges arise from a range of socio-cultural, economic, and environmental transformations that have increasingly disrupted the traditional balance between community, culture, and nature.

6.1 Modernization and Socio-Cultural Change

One of the major challenges to conserving Apatani traditional practices is the growing influence of modernization and changing lifestyles. Formal education, market-based economies and urban exposure have led younger generations to disengage from traditional farming, weakening the intergenerational transmission of indigenous knowledge. Government led development programs and infrastructure changes have further shifted the Apatani way of life toward mechanized farming and chemical inputs. There is an evident increased of youth migration thar has caused labour shortages, leading to greater dependence on hired workers who bring in non-local agricultural practices, diluting the indigenous system.[13]

Traditional soil and water conservation techniques are being replaced by concrete channels and plastic or lead pipes. This notably led to influx of external labourers that threatens the continuity of *Siigang*-based irrigation and other traditional practices, accelerating the disconnect from sustainable Apatani land-use systems.

6.2 Youth Disinterest and Migration

Rising educational levels have led Apatani youth to migrate for urban education and employment, resulting in declining interest in traditional farming.[14] This disengagement threatens the continuity of indigenous knowledge once passed down through participation. Older women particularly express concern over the loss of skills and ecological intimacy. The feminization of agriculture is increasing, with women managing homes and fields as men migrate. Farming is seen as labour-intensive and less rewarding than salaried jobs. All respondents voiced concern about youth disinterest in agriculture. A woman from Hari village remarked, "Today's youth care more about their skin than farming. They don't want to get tanned or dirty in the fields." Some elders noted that even when children inherit land, they often lease it out rather than cultivate it themselves.

6.3 Land Fragmentation and Population Pressure

With the increase in population, the available land per household has decreased. This has led to fragmentation of terraces and a shift in land use from agricultural to residential or commercial purposes. In recent years, farming in Ziro Valley has faced many challenges. Increasing population has led to the division of land into smaller plots, making farming less productive. Many young people are leaving farming to find government

[13] Sumpam Tangjang and P. K. Ramachandran Nair, *Integrated bamboo + Pine Homegardens: A Unique Agroforestry System in Ziro Valley of Arunachal Pradesh, ,* Delhi, 2016.

[14] Meghana et al., *The Apatani's Traditional Practices: A Model for Sustainability*, International Journal of Multidisciplinary Educational Research, Sucharitha Publications, 2023, PP. 64–70.

jobs.[15] As land becomes scarce, traditional farming systems become harder to maintain, both economically and practically. In some cases, fallow lands are no longer rotated properly, leading to reduced soil regeneration and productivity. With population growth in the region, pressure has increased on the traditionally sustainable land use systems. This has led to changes such as the introduction of kiwi farming to meet food demand and attract tourism.[16]

6.4 Weak Institutional Support

Despite the ecological value of the Apatani community's traditional land and water management systems, institutional support remains inadequate. Government policies rarely integrate indigenous knowledge into mainstream conservation or development strategies. Historically, the Apatani relied on customary institutions like the *Bulyang* (village council) to manage agriculture, irrigation and forests. However, modern governance has diminished the authority of these local institutions, weakening community-based resource management.[17]

Many interviewees expressed dissatisfaction with current farming schemes, stating they do not suit the Apatani system. A 64-year-old elder from *Bamin Michi* observed, "Schemes are often urban-centric or meant for large-scale farming, not for small terrace farms like ours." Traditional knowledge, still largely oral, lacks formal documentation and is absent from academic curricula and policy, increasing the risk of loss. Capacity-building programs and subsidies often promote mono-cropping or commercial models, conflicting with the integrated *Aji-Ngwyi* (rice-fish) system.[18] Even as Ziro Valley is listed on India's Tentative List for UNESCO World Heritage Sites, local community involvement remains limited.[19] The Stronger collaboration between government, scholars and Apatani leaders is urgently needed.

6.5 Climate Change and Environmental Stress

Climate change is a major threat to the traditional farming system in Ziro Valley, which combines wet rice cultivation, terrace farming and fish rearing. This system depends on regular rainfall and predictable seasons, both of which are now changing. The irregular monsoons and rising temperatures are making it difficult for farmers to plan their planting and harvesting, affecting both rice and fish yields. It is also noted that many natural springs and streams, which support bamboo-based gravity irrigation are drying up or becoming unreliable. Warmer temperatures are speeding up water loss from *Siigang* and paddy terraces. At the same time, extreme weather such as heavy rains, droughts and longer dry spells is leading to erosion, floods and lower soil fertility. A 60-year-old woman from Dutta shared that in June 2025, there was the heaviest rainfall in years that flooded her *Kiiley*-side field and washed away all the fish before harvest. Several farmers reported similar issues, especially for fields near rivers. Climate change is also increasing pests and crop diseases. To cope, some farmers are turning to chemical inputs, which may harm the organic *Aji-Ngwyi* system. Study warns that climate change, along with modernization may lead to the decline of traditional farming practices.[20]

6.6 Infrastructural Development and the Abandonment of Paddy Fields

In recent years, infrastructure growth in Ziro Valley has emerged as a major threat to the traditional land and water management practices. As population, tourism and economic activities grow, more houses, shops, hotels and recreational buildings are being built, often at the cost of valuable *Aji* (wet rice terraces). Many paddy

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[15] Patnaik, *Multifunctional Agriculture as a Holistic Tool in Addressing Sustainability Issues Among Mountain Communities of Ziro valley, Arunachal Pradesh*, Savitribai Phule Pune University, Pune, 2020.

[16] Tapi Taka & Sumpam Tangjang, *Sustainable Approach: Paddy-cum-fish and bamboo-cum-pine agroforestry in Ziro Valley, Arunachal Pradesh, India,* Journal of Bioresources, Doimukh, 2015. P.P. 50–57.

[17] D. Dolie & M. Dolie, *Customary Institutions and Traditional Governance Among the Apatanis of Arunachal Pradesh*, Journal of Tribal Intellectual Collective India, Mumbai, 2015, P.P. 43–55.

[18] Hana, *Modernity and Transformation in Tribal Life: A Study of the Apatani of Ziro Valley,* International Journal of Humanities and Social Science Invention, 2019.

[19] Persis Farooqy, *Symbiosis between Nature & Culture – A Case Study of the Apatani Cultural Landscape, India,* Journal of World Heritage Studies, 2017, P.P.51–55.

[20] Opcit. Padi Hana, 2019.

fields are being converted into sites for buildings, government offices and private homes. This not only reduces farmland but also damages the gravity-based irrigation systems and bamboo *Siigang*, which are getting blocked or disconnected due to construction. High demand for land in Ziro and Hapoli has encouraged landowners to sell or convert agricultural plots for profit. This shift makes farming seem less viable, especially to younger generations, who are moving toward real estate or service jobs.

While development brings benefits, without proper planning, it risks destroying the Apatani's centuries-old sustainable farming system, which is deeply rooted in local ecology and cultural tradition.

6.7 Emergence of a Cash Economy

The growing cash-based economy in Ziro Valley has reshaped the community's relationship with land and resources. While it has brought new income opportunities, it has weakened traditional, sustainable land and water management systems. The tribe once relied on subsistence-based wet rice and fish farming, guided by communal rules. But with market integration and access to salaried jobs, especially among youth, participation in traditional agriculture has declined which is affecting collective land stewardship. One major shift is the rise of commercial Kiwi farming. Though profitable, it often involves clearing forests or bamboo groves, leading to deforestation and loss of biodiversity. Unlike *Aji-Ngwyi* (rice-fish terraces), kiwi farms are individually managed and ecologically disruptive. Interviewees voiced concern that while kiwi brings income, it harms the environment and undermines traditional systems.[21]

The land is increasingly viewed as a commodity rather than a shared ecological asset. Land sales and fragmentation, especially around Hapoli area, are disrupting irrigation networks which is vital to rice-fish farming. The non-native bamboo species, like Chinese Moso, threaten local biodiversity. Therefore, a balanced approach is needed to protect both livelihoods and tradition.[22]

7. Recommendations for Conserving Apatani Traditional Land and Water Practices

a) Revitalizing Traditional Institutions and Customary Governance

One of the key ways to protect Apatani traditional practices is to strengthen the authority of the *Bulyang* (village council), which has long been responsible for managing resources like land, water and forests. However, the council needs a formal recognition from government so that through laws and policies matters can be addressed and resolved lawfully. This would allow them to work alongside official institutions in managing agriculture and natural resources. By restoring their role in decision-making, the community can rebuild collective responsibility and protect their ecological systems. Furthermore, involving the *Bulyang* in policy discussions ensures that development plans align with local knowledge and values. Customary rules about water distribution, forest usage, and seasonal farming cycles can be included in local governance structures. This would make conservation efforts more culturally appropriate and community-driven.

b) Youth Engagement and Knowledge Transmission

To protect traditional knowledge, it is vital to involve young generation in cultural and ecological practices. Schools in Ziro Valley should include lessons on traditional farming, bamboo-based irrigation, and forest use. Documenting oral traditions and converting them into teaching materials can help students learn their heritage in a structured way. By documenting indigenous knowledge, integrating it with science, and promoting youth participation the practice can be preserve and transmit from generation to generation. Training programs, fellowships, or apprenticeships can teach traditional skills like *Aji-Ngwyi*, composting, and terrace repair—offering both knowledge and income. Such efforts may help youth understand value in continuing these practices. Workshops and intergenerational events led by elders can further strengthen cultural continuity and community bonds while preserving sustainable land and water management system of the Apatani tribe.

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[21] Opcit. D. Dolie, 2021, P.P. 55–62.

[22] Opcit. Tapi Taka & Sumpam Tangjang, 2015.

c) Policy Reforms and Institutional Support

Government policies should better support Apatani traditional farming, which relies on small-scale, integrated methods like *aji-ngwyi* (rice-fish farming), bamboo irrigation and terrace cultivation. Current schemes often favour large-scale agriculture, which doesn't suit Ziro Valley. Schemes like RKVY and MGNREGA should include specific provisions for indigenous practices. Financial incentives and subsidies can motivate farmers to continue these methods. Community seed banks and organic composting centers, developed with local research institutions and KVKs, can help reduce chemical use. Training programs must consider local conditions and promote traditional techniques instead of unsuitable external technologies. By combining farmer training with ecotourism and recognition of the Apatani system's ecological value must be preserved and continued.

d) Climate Adaptation and Ecological Solutions

Since climate change is impacting rainfall patterns and reducing water availability, the community needs to upgrade and align its traditional irrigation systems with current situation. One way to do this is by combining bamboo-based gravity irrigation with modern water-harvesting methods like storage tanks and slow-sand filters. These upgrades can make the system more reliable while still being eco-friendly. To prevent soil erosion and protect farmlands from floods, agroforestry practices can be expanded. This means planting trees and bamboo along terraces and fields to serve as living barriers. These bio-shields also improve water retention and reduce damage during extreme weather. Introducing crop varieties that are resistant to droughts or pests, while still being close to traditional types can also help farmers adapt to changing conditions. Local agricultural institutions must assist in identifying and distributing such varieties.

e) Regulation of Infrastructural Development

Rapid construction of roads, buildings and commercial sites in Ziro Valley is damaging traditional *Aji* (paddy terraces). To protect these, strict land-use policies should classify paddy fields and forests as heritage zones, preventing their conversion to non-agricultural use. Tourism should be regulated by encouraging eco-friendly construction using materials like bamboo and wood. Local building codes can promote sustainable architecture and prevent overdevelopment. To support farmers, the government could provide tax benefits or subsidies for maintaining paddy fields, making traditional farming more financially attractive. Improving education and local job opportunities is also essential. As this would help youth stay in the valley and remain connected to traditional practices, slowing their decline.

f) Sustainable Economic Alternatives and Market Integration

Economic development and conservation do not have to be separate goals. By promoting organic and traditional Apatani products such as rice and fish as premium ecological goods, local farmers can earn better incomes. Branding and certification (such as "organic" or "GI tag") can be used to market these products in cities. Combining modern methods with traditional practices may help increase productivity without harming the environment or the cultural integrity of Apatani farming systems. For cash crops like Kiwi, which is gaining popularity, community-owned plantations should be promoted. This would prevent the clearing of forests by individuals and ensure environmental guidelines are followed. The profits can be shared among members, making it a more sustainable and equitable model. In addition, youth should be trained in eco-tourism, bamboo craft, herbal medicine and other livelihood options that depend on maintaining local biodiversity. These alternatives can reduce the community's dependence on jobs that require them to leave traditional farming behind.

Conclusion

The Apatani community of Ziro Valley offers a strong example of how indigenous knowledge and cultural values can support sustainable land and water management. Their Agro-ecological system, which combines *Aji-Ngwyi* on terraced fields, has developed over centuries through observation, adaptation and communal

effort. This system supports biodiversity, soil fertility and water conservation without relying on chemicals or machines. A key strength of the Apatani model is the gendered division of labour. Men are mainly responsible for building and maintaining terraces, *Siigang* and managing forests and bamboo groves. Women handle seed selection, transplanting, weeding, composting and home gardens. Their knowledge of soil health and pest control is essential for ecological balance. Together, their roles create a cooperative and sustainable model of resource management. However, the system now faces serious challenges. Modernization, youth migration, land fragmentation, weak institutional support and climate change are eroding traditional practices. Infrastructure growth, a rising cash economy and the shift to commercial crops like Kiwi are also disrupting the ecological and cultural balance.

Despite these pressures, the Apatani system still offers valuable lessons for sustainable development. This study shows that its survival depends on strengthening traditional institutions, documenting knowledge, involving youth, and aligning conservation with economic opportunities. Policies must support indigenous practices and ensure the active involvement of both men and women in decision-making. Recognizing and respecting gender-specific roles is vital for sustaining this unique and resilient farming system. Although the study was carefully planned with meticulous attention to detail, it may still contain certain inherent limitations. The research is restricted to the objectives and scope defined for the subject under investigation. Furthermore, the study relies on secondary sources and primary data collected from a limited number of selected respondents. The study faced certain limitations, such as the non-availability of resources and difficulties in contacting the desired informants for personal interviews. Despite these constraints, the research was conducted with utmost honesty and sincerity, and the findings effectively reflect the objectives of the study.

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